MULTIMEDIA UNIVERSITY®

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

EMF2016 ELECTROMAGNETIC THEORY

(All Sections / Groups)

24 OCT 2017
02:30 P.M – 4:30 P.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 10 pages including this cover page with 4 questions only. Common constants for air are listed on Page 5.
2. Attempt all four questions. All questions carry equal marks and the distribution of marks for each question is given.
3. Please print all your answers in the answer booklet provided.
4. Please tie and submit worked Smith charts together with the answer booklet.

Question 1

(a) A 2 GHz source is connected to a load Z_L with impedance $(30 + j30)\,\Omega$ via a 1 m 50 Ω lossless coaxial cable filled with polyethylene (dielectric constant $\varepsilon_r = 2.25$). Without using Smith chart, compute the following parameters.

(i) The phase constant.

[3 marks]

(ii) The reflection coefficient at the load.

[3 marks]

(iii) The location of the first voltage maximum from the load.

[4 marks]

(b) Using Smith charts (provided at the end of this question paper), design a single stub tuner (use 50 Ω shunt short-circuited stub) to match a $(30 + j30)$ Ω antenna to a 50 Ω transmission line, by finding

(i) the shortest electrical distance between the stub and the antenna and

[8 marks]

(ii) the stub electrical length.

[7 marks]

(**You need to submit the worked Smith charts.** Write all markings and labels clearly. Detach them from the question paper and tie them to your answer booklet.)

Continued ...

Question 2

(a) Write down the four Maxwell equations in differential form and the physical laws they represent.

[8 marks]

(b) Show that $\underline{\nabla} \cdot \underline{\mathbf{J}} = -\dfrac{\partial \rho_v}{\partial t}$ is consistent with the principle of conservation of charges which states, "no charge can be spontaneously created or destroyed". $\underline{\mathbf{J}}$ and ρ_v are conduction current density and volume charge density, respectively.

[6 Marks]

(c) Using Ampere's law, show that the magnetic flux density due to an infinitely long straight wire carrying a current I is given by

$$\underline{\mathbf{B}} = \hat{\boldsymbol{\varphi}} \frac{\mu I}{2\pi\rho}.$$

[4 marks]

(d) A conducting rod AB moves in air at a constant velocity of 2 m/s in parallel to an infinitely long straight wire carrying a constant current of 9 A, as shown in Fig. Q2. Determine the potential difference $\mathbf{V_{AB}}$ developed in the rod AB. Take note the polarity of V_{AB}.

[7 marks]

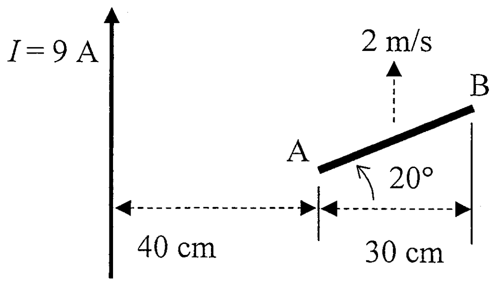

Fig. Q2

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Question 3

The electric field of a plane wave propagating in a nonmagnetic medium is given by

$$\underline{\mathbf{E}} = \hat{\mathbf{x}}\,3\sin\left(\pi \times 10^7 t - 0.3\pi\, y\right) + \hat{\mathbf{z}}\,4\cos\left(\pi \times 10^7 t - 0.3\pi\, y\right) \text{ (V/m)}.$$

(a) Determine the following:

(i) The frequency.

[2 marks]

(ii) The phase velocity.

[2 marks]

(iii) The dielectric constant of the medium, ε_r.

[2 marks]

(iv) The wave impedance.

[2 marks]

(v) The magnetic field intensity vector, $\underline{\mathbf{H}}$.

[5 marks]

(b) The plane wave impinges on a plane medium interface at $y = 0$ at normal incidence. The medium at $y > 0$ is air. Determine

(i) the reflected electric field intensity vector, and

[6 marks]

(ii) the transmitted electric field intensity vector.

[6 marks]

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Question 4

(a) Explain the fundamental differences between transverse electric (TE), transverse magnetic (TM) and transverse electromagnetic (TEM) waves.

[3 marks]

(a) Define the terms "cutoff frequency" and "dominant mode" in a waveguide.

[4 marks]

(b) A rectangular waveguide with dimensions 2.5 cm × 1 cm is to operate at 15 GHz. Given that the waveguide is filled with a medium characterized by conductivity $\sigma = 0$, relative permittivity $\varepsilon_r = 4$, and relative permeability $\mu_r = 1$, calculate for TE_{10} mode,

(i) the cutoff frequency,

[4 marks]

(ii) the phase constant,

[3 marks]

(iii) the guide wavelength,

[2 marks]

(iv) the phase velocity,

[3 marks]

(v) the group velocity, and

[3 marks]

(vi) the wave impedance.

[3 marks]

Common constants for air

Speed of light, c =	3×10^8 m/s
Permittivity, ε_0 =	8.854×10^{-12} F/m
Permeability, μ_0 =	$4\pi \times 10^{-7}$ H/m
Intrinsic impedance, η_0 =	377 Ω

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The Complete Smith Chart

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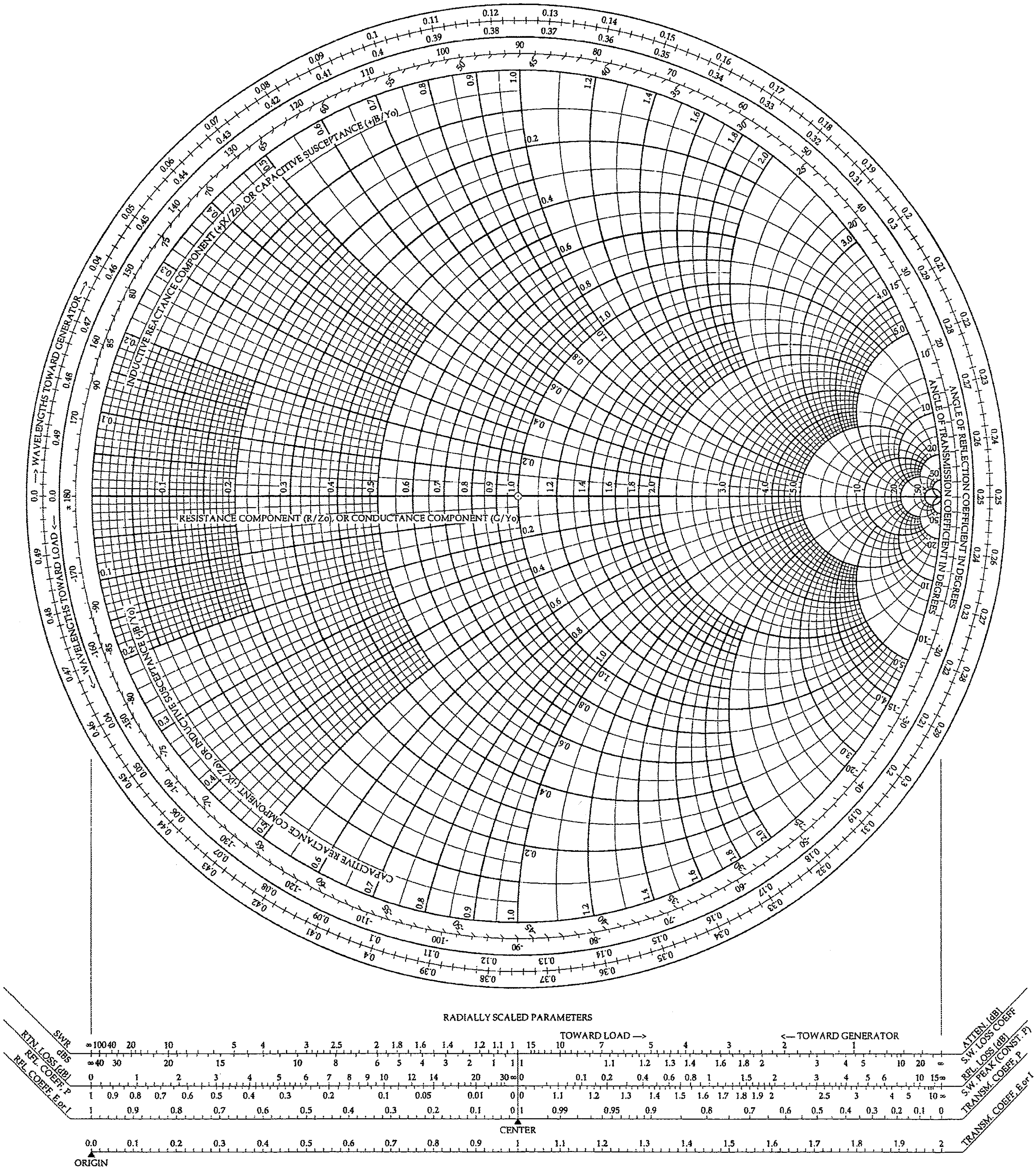

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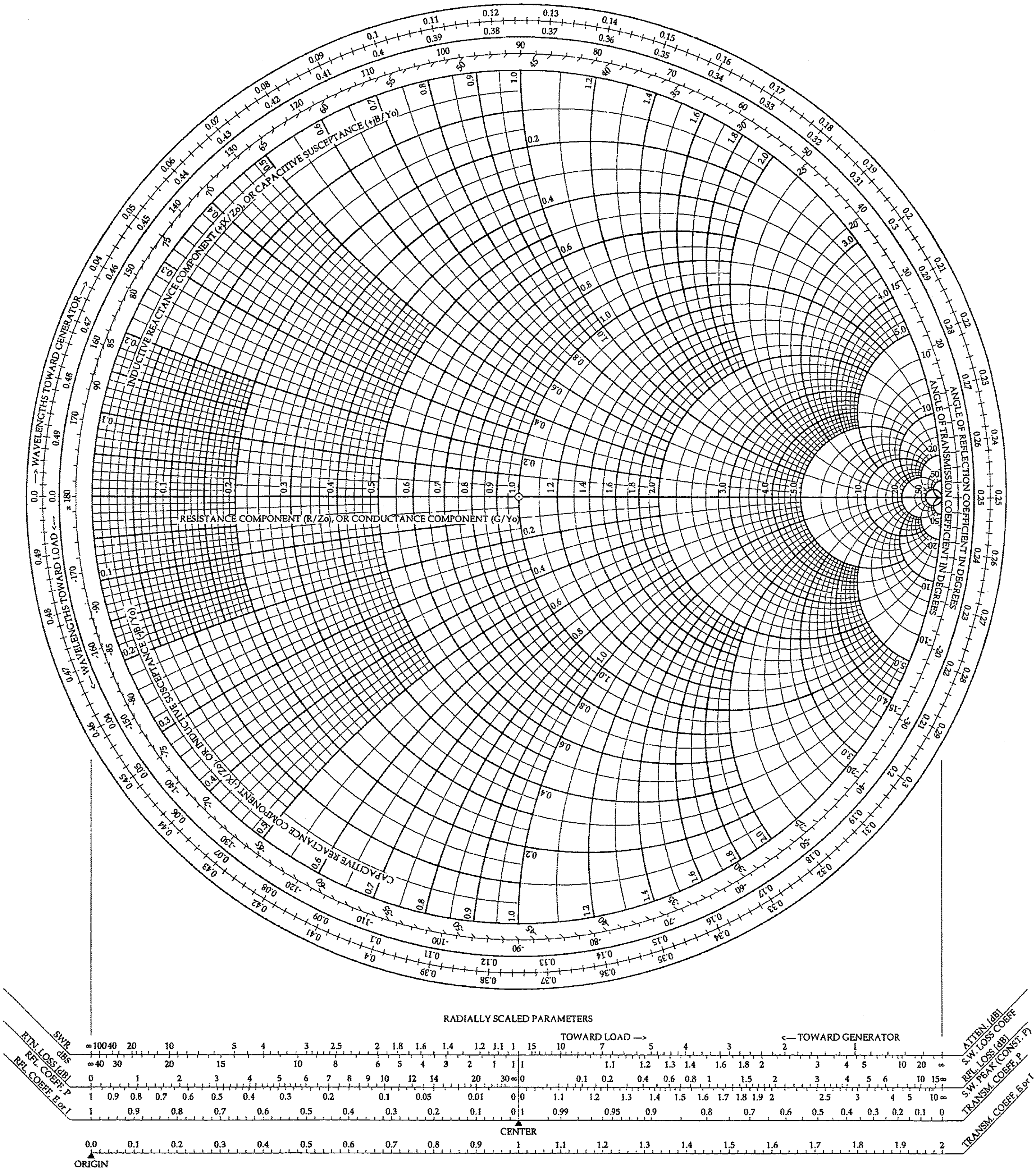
The Complete Smith Chart

Black Magic Design



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The Complete Smith Chart

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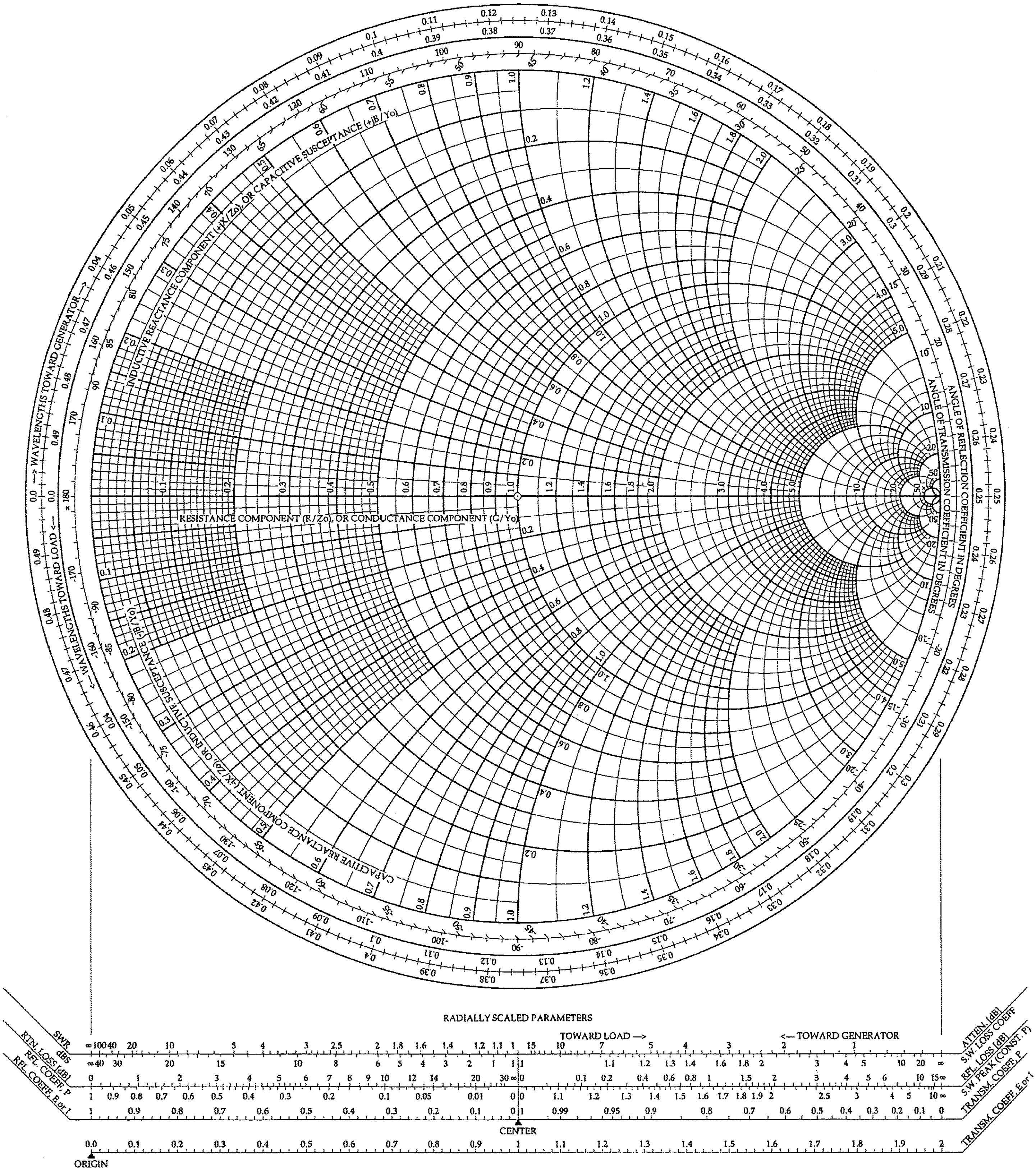

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The Complete Smith Chart

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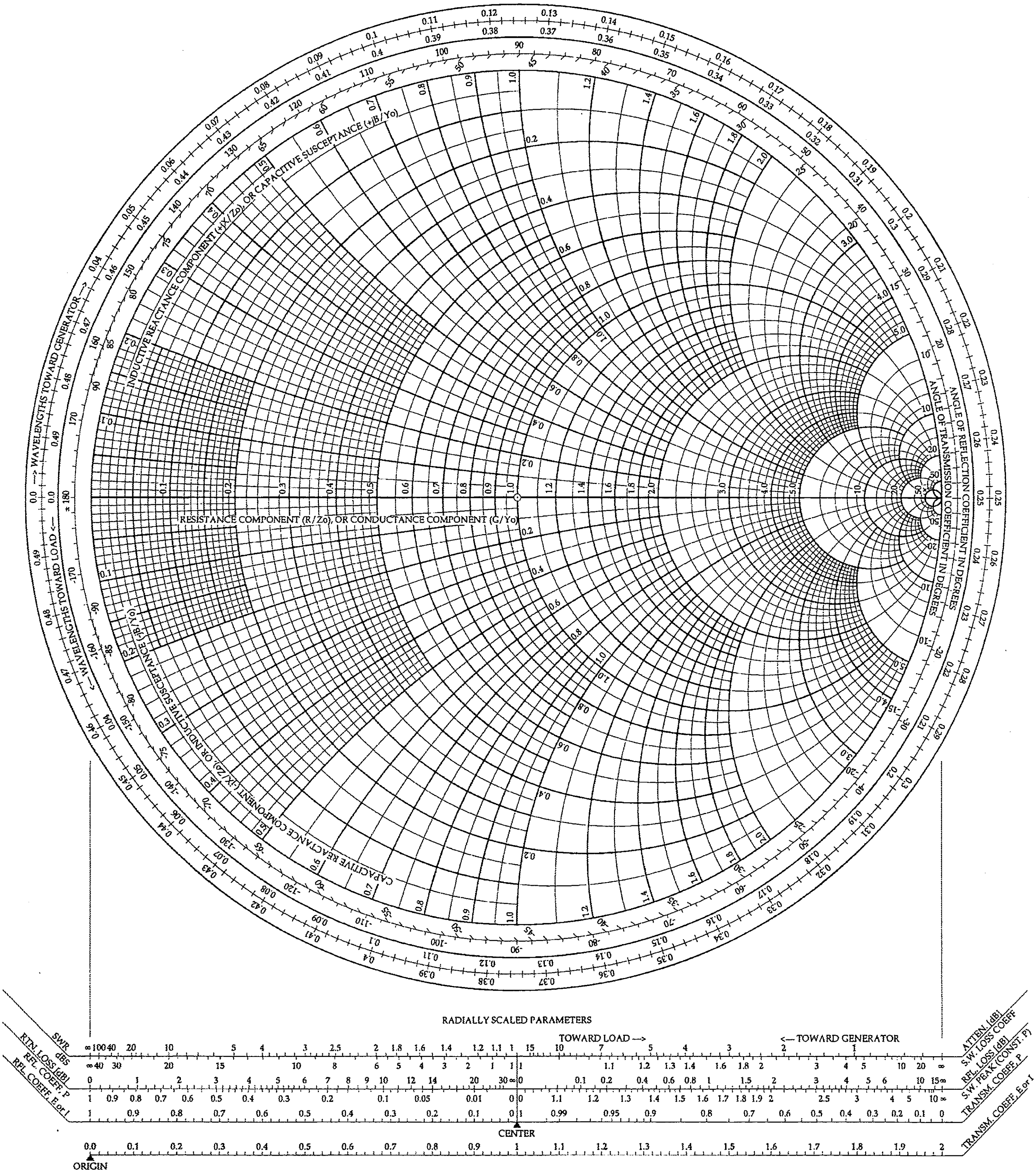

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